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Maize phenology alters the distribution of enzyme activities in soil: Field estimates

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A B S T R A C T

Microbial processes mediated by soil enzymes are crucial in soil organic matter decomposition, resulting in release of nutrients that become available for plant and microbial uptake. Therefore, it is crucial to know the sensitivity of enzyme activities (EA) along soil depths at distinct plant vegetation stages, and how the availability of mineral nitrogen (N) alters EA. We studied effects of N fertilization (0 and 160 kg N ha^{-1}), soil depth (0–35 cm), and plant-phenological stage (silking and maturity) on microbial biomass C (C_{mic}) and potential activities of C-, N- and P-acquiring enzymes in the field under *Zea mays* L.

Nitrogen fertilization increased shoot biomass by more than 80% compared to unfertilized plants. Maize roots triggered increases in C_{mic} and EA for all measured enzymes compared to bare fallow. Stimulating effect of plant roots on EA was enzyme specific and stronger at silking than maturity stage of maize. The down-regulating effect of N fertilization on EA involved in acquiring N was most pronounced on the activity of L-leucine amino-peptidase and β-1,4-*N*-acetylglucosaminidase. Soil depth was the primary determinant of EA, explaining up to 51% of the variation. Depth-dependent EA changes were stronger in rooted soil.

A pronounced biotic control on EA was demonstrated by higher EA in rooted soil than in bare fallow. This confirmed root-mediated microbial activation. Stronger effect of silking vs. maturity stage on EA indicated that actively growing roots fuel microorganisms via root-derived organics. Thus, soil depth and plant roots were major factors controlling microbial activity in arable soil.

1. Introduction

Food security will be a vital issue in meeting the demand of an increasing global population. Thus, there is renewed interest in understanding the biochemical processes in agricultural soils, and how altering these processes may be used to increase agricultural productivity. Such sustainable agricultural practices offer tremendous opportunities for maintaining or increasing soil health (i.e. fertility) (Doran and Zeiss, 2000). Sustainable agriculture refers to maintenance or enhancement of soil health with minimum disturbance and has laid the foundation for understanding soil ecological functioning (Ferrarini et al., 2017; Weiner, 2017). Soil microorganisms are central to ecological functioning (Bender et al., 2016). A better understanding of microbial functioning will help to elucidate the biogeochemical processes contributing to nutrient transformations in soils (Nannipieri et al., 1978, 2003). Decomposition and transformation of soil organic matter (SOM), nutrient mobilization/immobilization, and aggregate formation/stabilization are among the most important processes predominantly governed by microorganisms (Nsabimana et al., 2004; Six et al., 2004; Caldwell, 2005). The cycling of major nutrient elements is widely associated with enzyme activity (EA) in soil (Burns et al., 2013). EA is important in maintaining soil health, as enzymes catalyze the bottleneck steps in SOM decomposition and consequent release of nutrients for plant and microbial uptake (Aon et al., 2001). Generally, EA is

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